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Feedback mechanisms between fluid flow, deformation and mineral reactions in mid-crustal shear zones: insights from the Mont Blanc Massif (Western Alps)

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Feedback mechanisms between deformation, fluid flow, rheology and mineral reactions are evidenced in the Mont-Blanc Massif granite. Mid-crustal shear zones of 1 mm-50 m size dated by Ar-Ar on phengite at c. 15.8 $\pm$0.2 Ma, formed during the Alpine orogenesis, have localised intense fluid-flow, which produced substantial differences in mineralogy and whole-rock geochemistry. The deformation in this actively extruding pop-up structure is always compressive, with conjugate dextral SW-NE and sinistral N-S components. Four metamorphic parageneses are distinguished in shear zones, occurring in distinct areas of the massif: (i) epidote, (ii) chlorite-phlogopite, (iii) actinolite-muscovite $\pm$ biotite and (iv) muscovite $\pm$ biotite $\pm$ calcite. Mg# (Mg/(Mg+Fe)) pattern of phyllosilicates shows a bell-type pattern with low Mg# values on the massif NW and SE rims and high Mg# in the massif core shear zones. This is also reflected by the stable isotopic composition of calcite in shear zones, with low δ^{13}C in the massif core and high δ^{13}C at the rims. Calculations based on shear zones geochemistry show that substantial volume gains and losses have generally occurred during deformation. These reflect large fluid flow, directed upwards in the massif's core shear zones and downwards at the massif rim's. The difference in mineral alteration types, mineral chemistry and whole-rock composition are likely

due to variations in fluid/rock ratio, and fluid chemistry. These, in turn, influenced the deformation style, which remained brittle in the epidote zone, while it became ductile in the phlogopite/chlorite and muscovite zones.